CLOUDSAT

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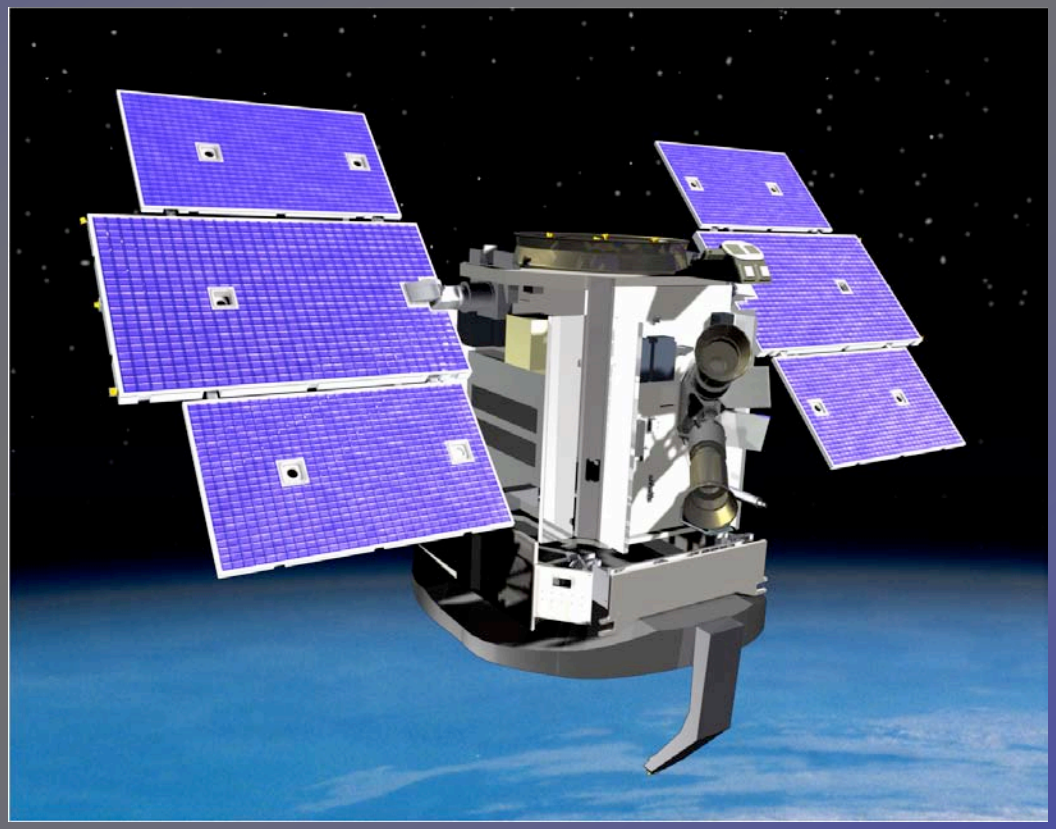
CloudSat Update



Deborah Vane

AIRS Science Team meeting

15 April 2008

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Outline:

1. Quick CloudSat overview and project status
2. Standard products
3. CloudSat/AIRS comparisons and complementarity
4. Planned ‘enhanced’ products
5. Summary

CloudSat: A brief overview and status

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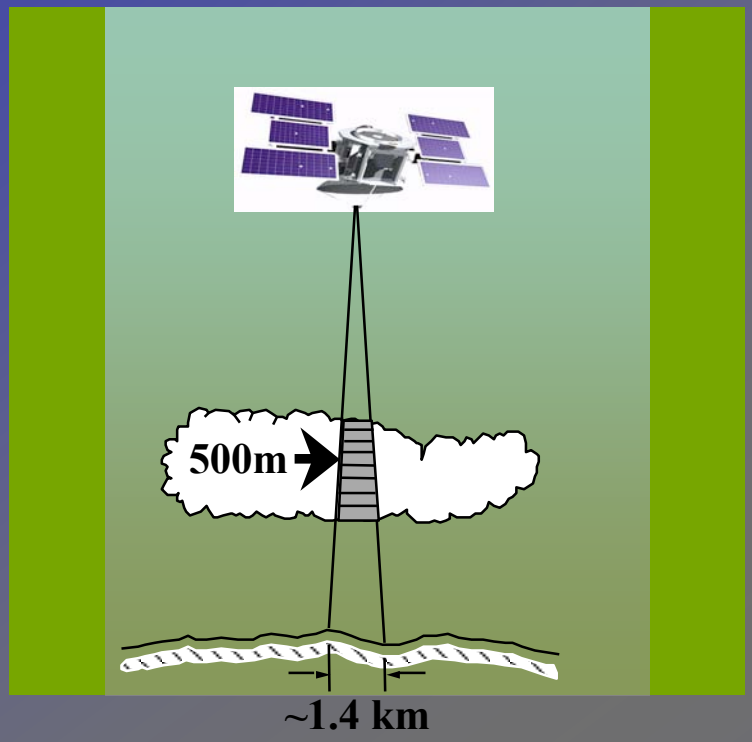

Hardware continues to operate with nominal performance on 'Side A'

Prime Mission accomplished Feb 08

CloudSat approved to operate through FY11

Two main components of design

1. Formation with the A-Train = a multi-platform observing system

2. The Cloud Profiling Radar (CPR)

- Nadir pointing, 94 GHz radar
- 3.3μs pulse ➔ 480m vertical res, over- sampled at ~240m
- 1.4 km horizontal res.
- Calibration better than 2 dBZ
- Sensitivity ~ -28 dBZ (-31 dBZ)
- Dynamic Range: 80 dB

CloudSat Data Distribution Summary

(As of 1/31/08)

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	Product Files	Data Volume (Tbytes)
CloudSat Internal Users	421,204	22.1
External Users	961,881	51.1
Total	1,383,085	73.2

Top External Users by Center (>5000 files)	Country
Jet Propulsion Laboratory	United States
NASA	United States
Institute of Atmospheric Physics	China
Tohoku University	Japan
Kyoto University	Japan
ICARE / LOA	France
NRL	United States
University of Washington	United States
University of Miami	United States
Max-Planck-Institut f. Meteorology, Hamburg	Germany
TRMM	United States
NASA Langley NASA / SAIC	United States
NASA GSFC	United States
University of Science and Technology	China
Lanzhou University	China
Chalmers University of Technology	Sweden
Peking University	China
University of Maryland	United States
Nanjing University Information Science and Technology	China
Florida State University	United States
Meteorological Service of Canada	Canada
University of Bologna	Italy
University of Washington	United States
Seoul National University	South Korea
NICT, JAPAN	Japan
EAPRS Lab. De Montfort University	United Kingdom
California Institute of Technology	United States
National Institute of Information and Communications Technology	Japan
University of Bonn	Germany
NASA Langley Research Center	United States
Osaka Prefecture University	Japan
Texas A and M University	United States
University of Wisconsin - Madison	United States

47 Countries (Alphabetical)	
1	Argentina
2	Australia
3	Austria
4	Brazil
5	Cameroon
6	Canada
7	Chile
8	China
9	Columbia
10	Cost Rica
11	Croatia
12	Czech Republic
13	Ecuador
14	Ethiopia
15	Finland
16	France
17	Germany
18	Greece
19	India
20	Indonesia
21	Iran
22	Israel
23	Italy
24	Japan
25	Malaysia
26	Nigeria
27	Norway
28	Pakistan
29	Peru
30	Poland
31	Portugal
32	Puerto Rico
33	Qatar
34	Russia
35	Scotland
36	Singapore
37	South Africa
38	South Korea
39	Spain
40	Sweden
41	Switzerland
42	Taiwan
43	Thailand
44	The Netherlands
45	Turkey
46	United Kingdom
47	United States

CloudSat
Standard & Enhanced Products

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Standard Product ID	Description
Level 1 (Since 2 June 2006)	
1A-AUX	Auxiliary data for navigation altitude assignments, raw CPR data
1B-CPR (RELEASED)	Calibrated radar reflectivities
Level 2 (Since 2 June 2006, Except 2B-GEOPROF-LIDAR)	
2B-GEOPROF (RELEASED)	Cloud geometric profile – includes a cloud mask (with confidence measure), reflectivity (significant echoes), (gas) attenuation correction, and MODIS mask
2B-GEOPROF-LIDAR (IN DEV.)	Merged radar and lidar cloud masks
2B-CLDCLASS (RELEASED)	8 classes of cloud type, including likelihood of mixed phase conditions
2B-TAU (RELEASED)	Cloud optical depth by layer, also effective radius (column)
2B-CWC (RELEASED)	Cloud liquid water content (2B-LWC) Cloud Ice water content (2B-IWC)
2B-FLXHR (RELEASED)	Atmospheric radiative fluxes and heating rates
Level 3 (In Development)	
3B-zonal-mon 3B-zonal-sea	Zonally averaged distributions of clouds derived from averaging 2B-geoprof

Standard Product ID	Description
Auxiliary Data Products (Since 2 June 2006)	
MODIS-AUX	MODIS radiances and cloud mask products
AN-MODIS	MODIS 1B radiances and 2B products subsetted about the CloudSat footprint
AN-SSF	CERES Single Satellite Footprint (SSF) products matched to CloudSat ground track
AN-state variables	Subset along track of various forecast model state variables, energy fluxes, etc.
Enhanced Products (In Development)	
2B-rain Precipitation (liquid)	Surface rainrate, profiles of liquid water content in precipitation
2B-snow Precipitation (solid)	Profiles of snow particle size distribution parameters and snowfall rate
2B-CC-ICE	Profiles of number concentration, particle size and ice water content
AN-PR	TRMM PR reflectivities and rainfall products matched to CloudSat reflectivity and rainfall products
AN-AMSRE	AMSR radiances and products matched to
Special Products (available from NRL-Monterey)	
TC-CloudSat	Hurricane overpass dataset

CloudSat Level 2 product examples

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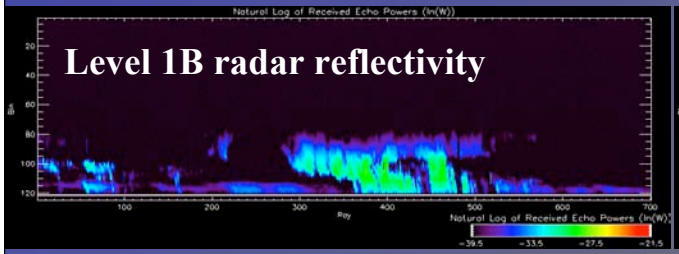

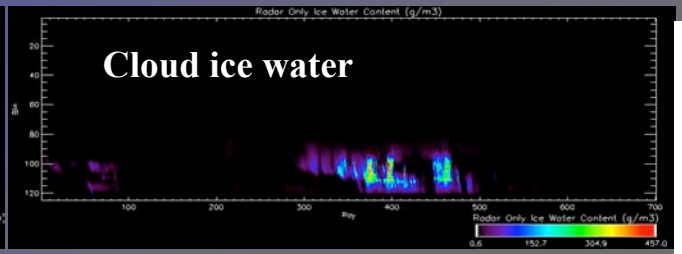

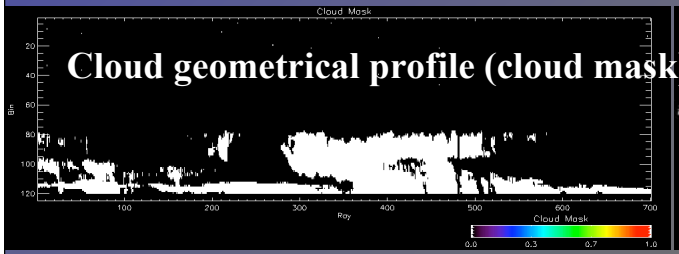

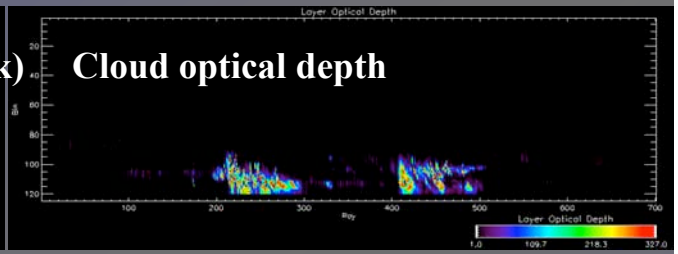

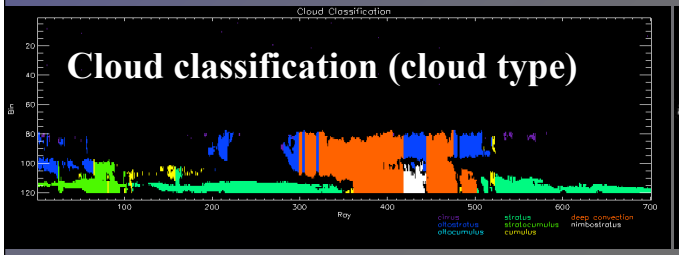

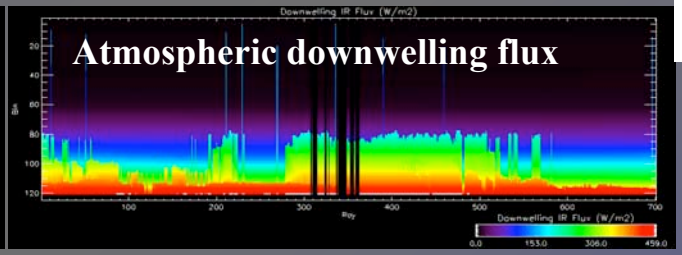

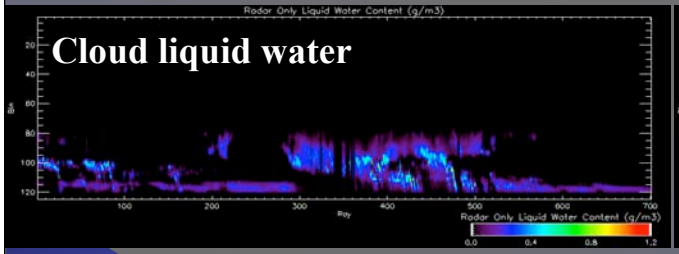

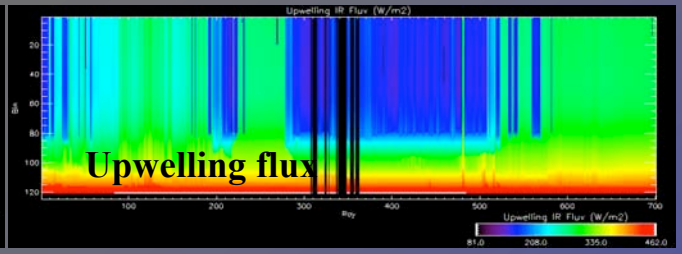

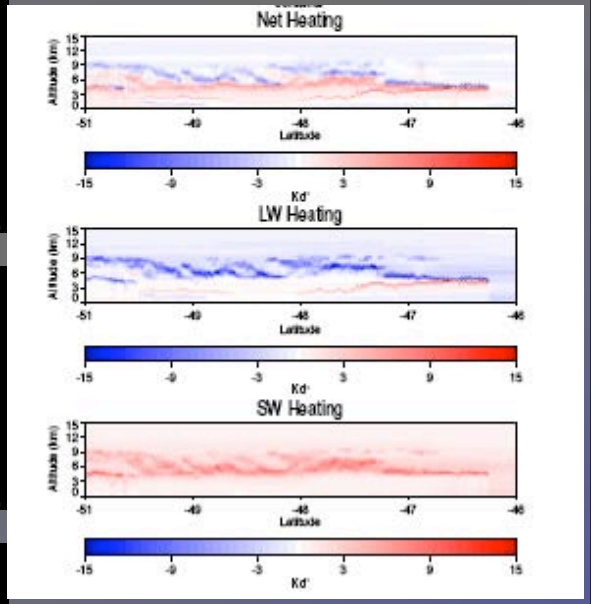

CloudSat L2B GEOPROF-Lidar

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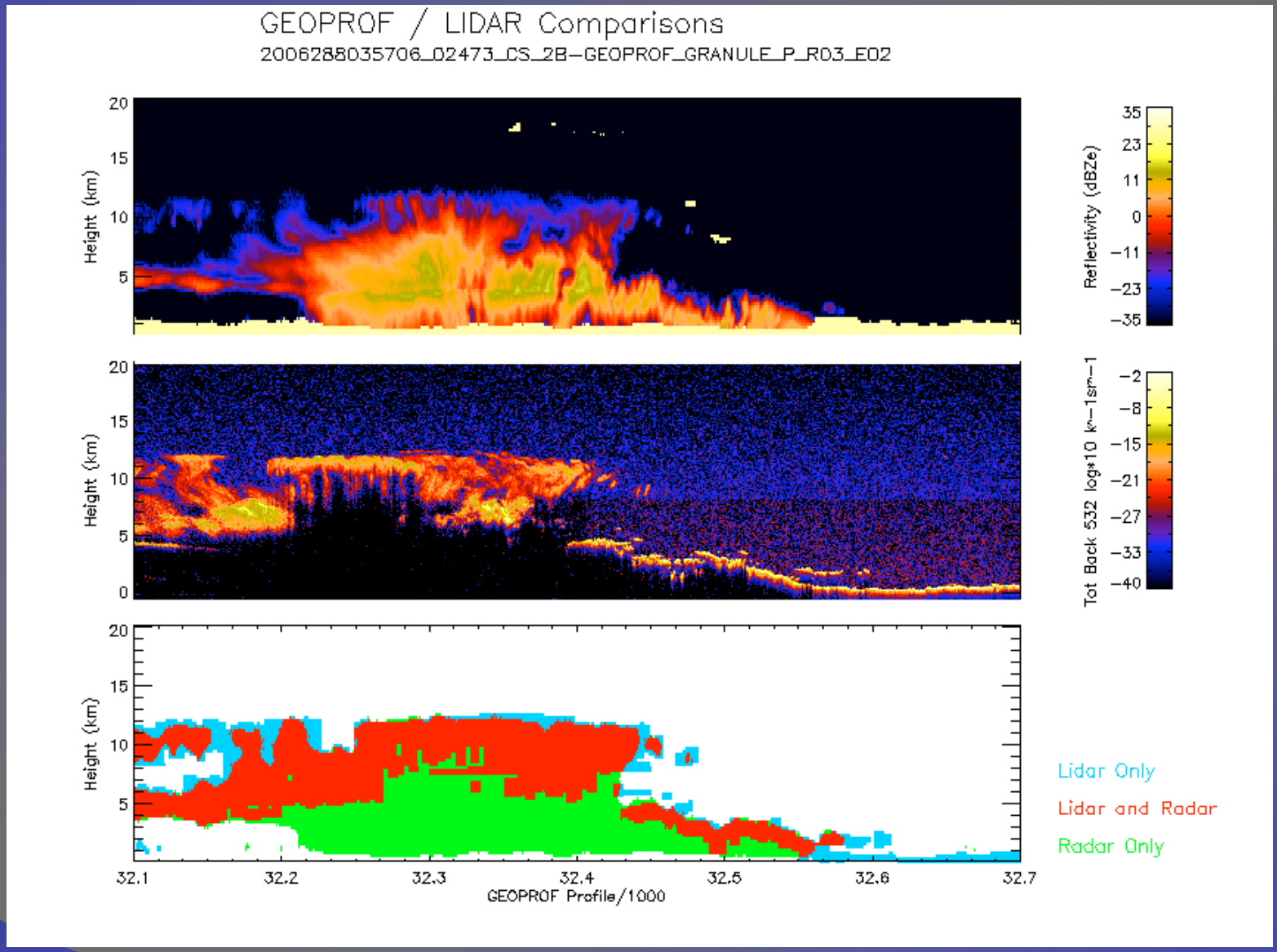

CloudSat L2B GEOPROF-Lidar

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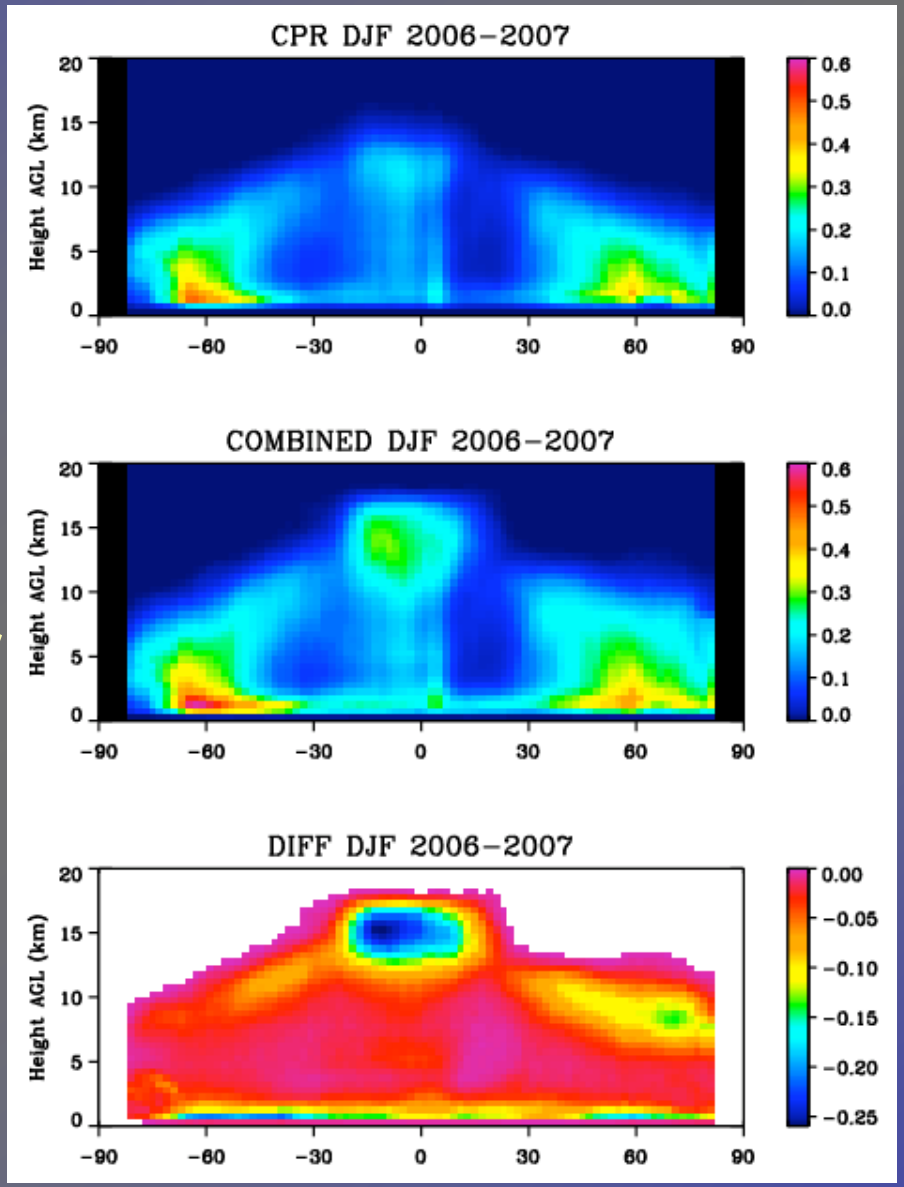
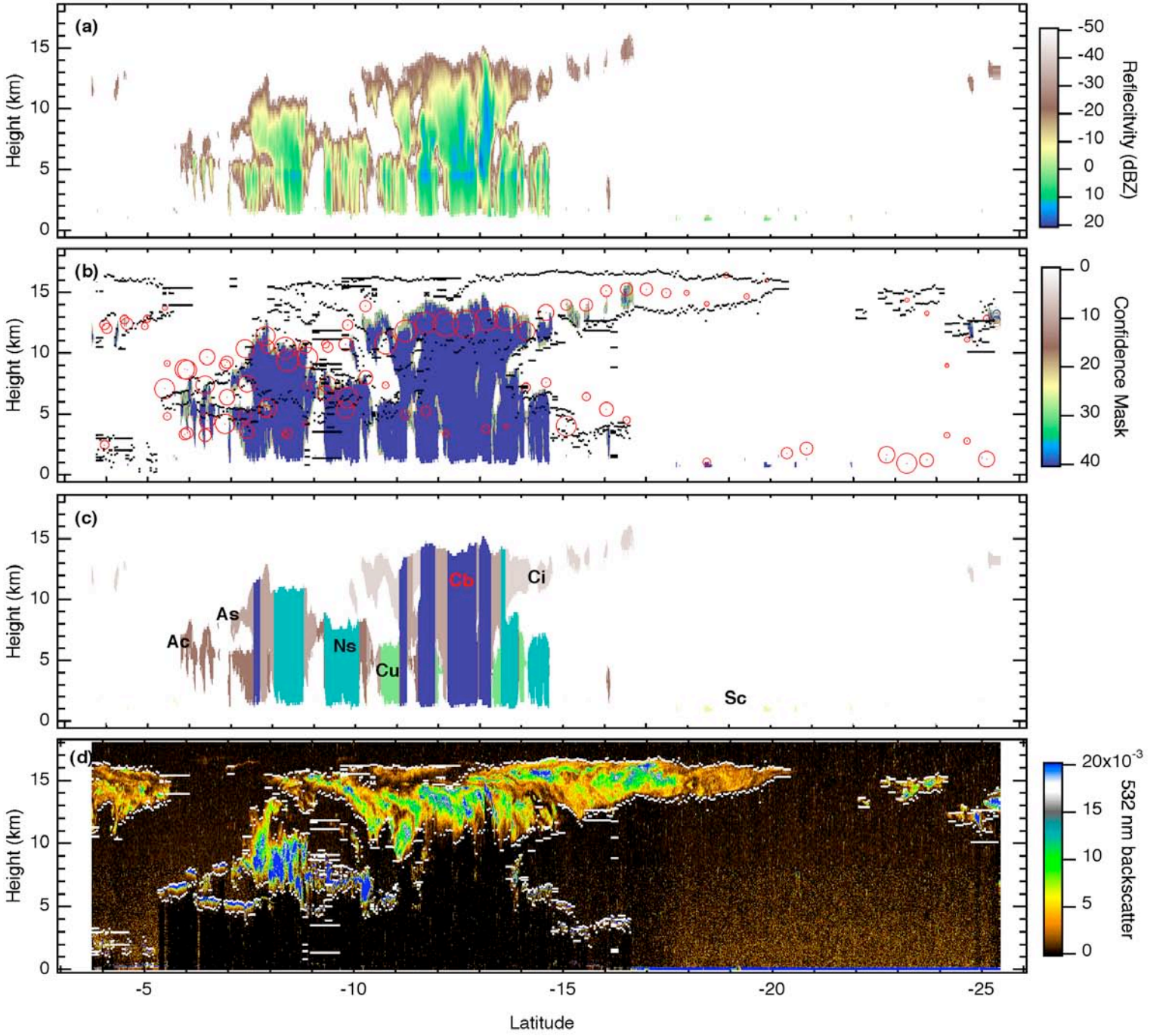
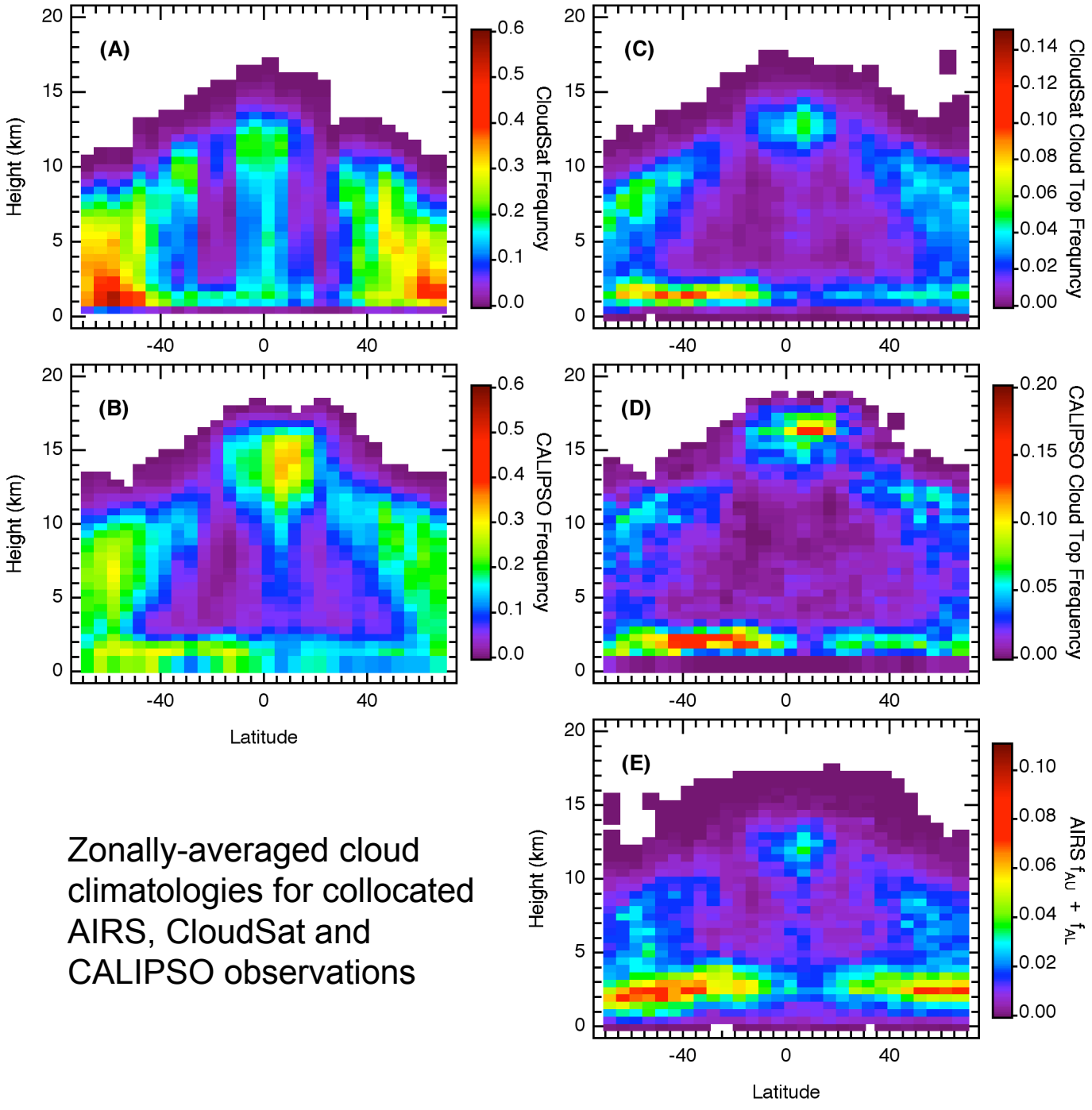
Radar
2B-GEOPROF

Radar+lidar
2B GEOPROF-Lidar

Difference




(a)
(b)
(c)
(d)
Height (km)
Reflectivity (dBZ)
Confidence Mask
532 nm backscatter
20x10-3
Ac
As
Ns
Cu
Cb
Ci
Sc
Latitude



Zonally-averaged cloud climatologies for collocated AIRS, CloudSat and CALIPSO observations

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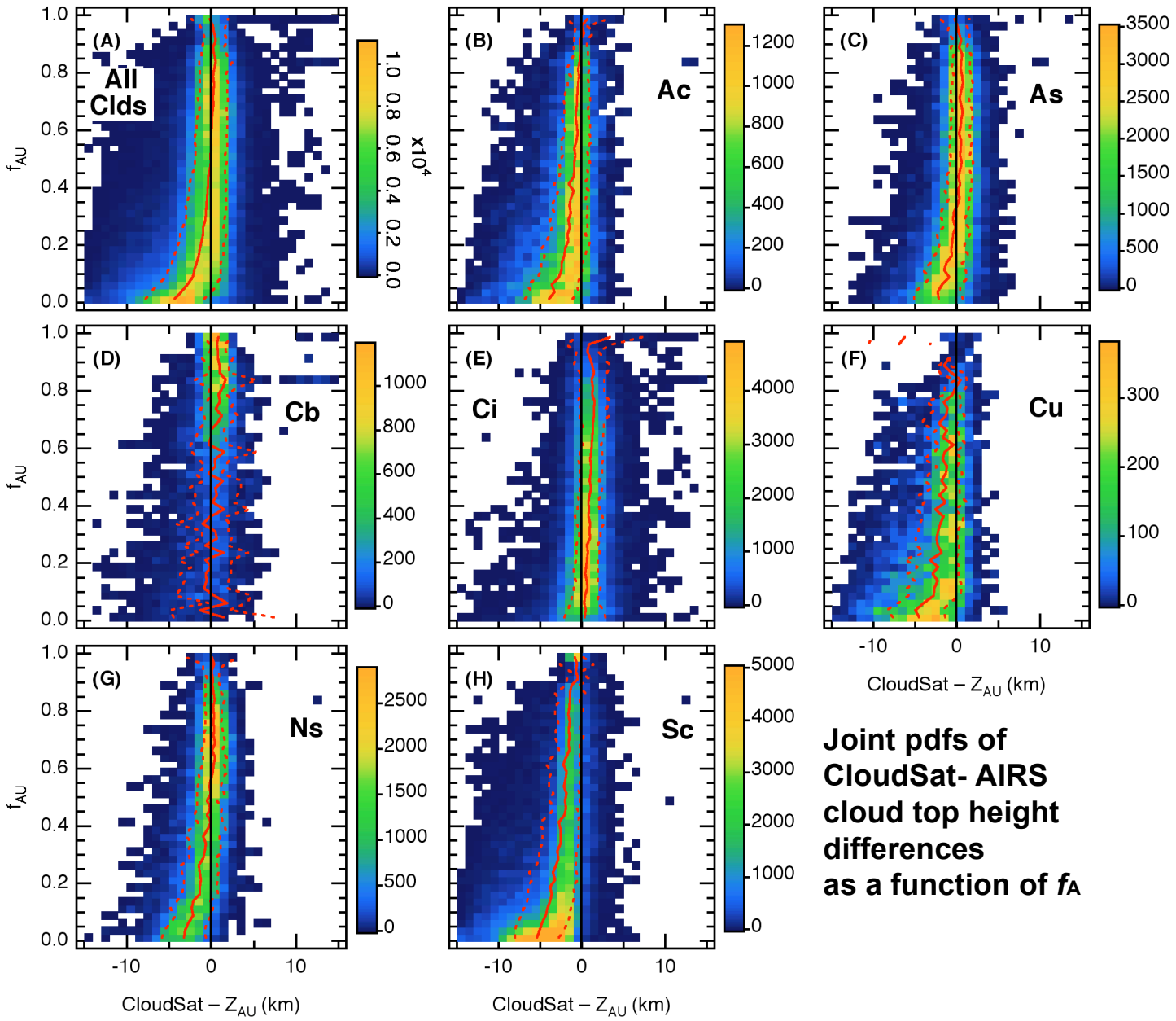
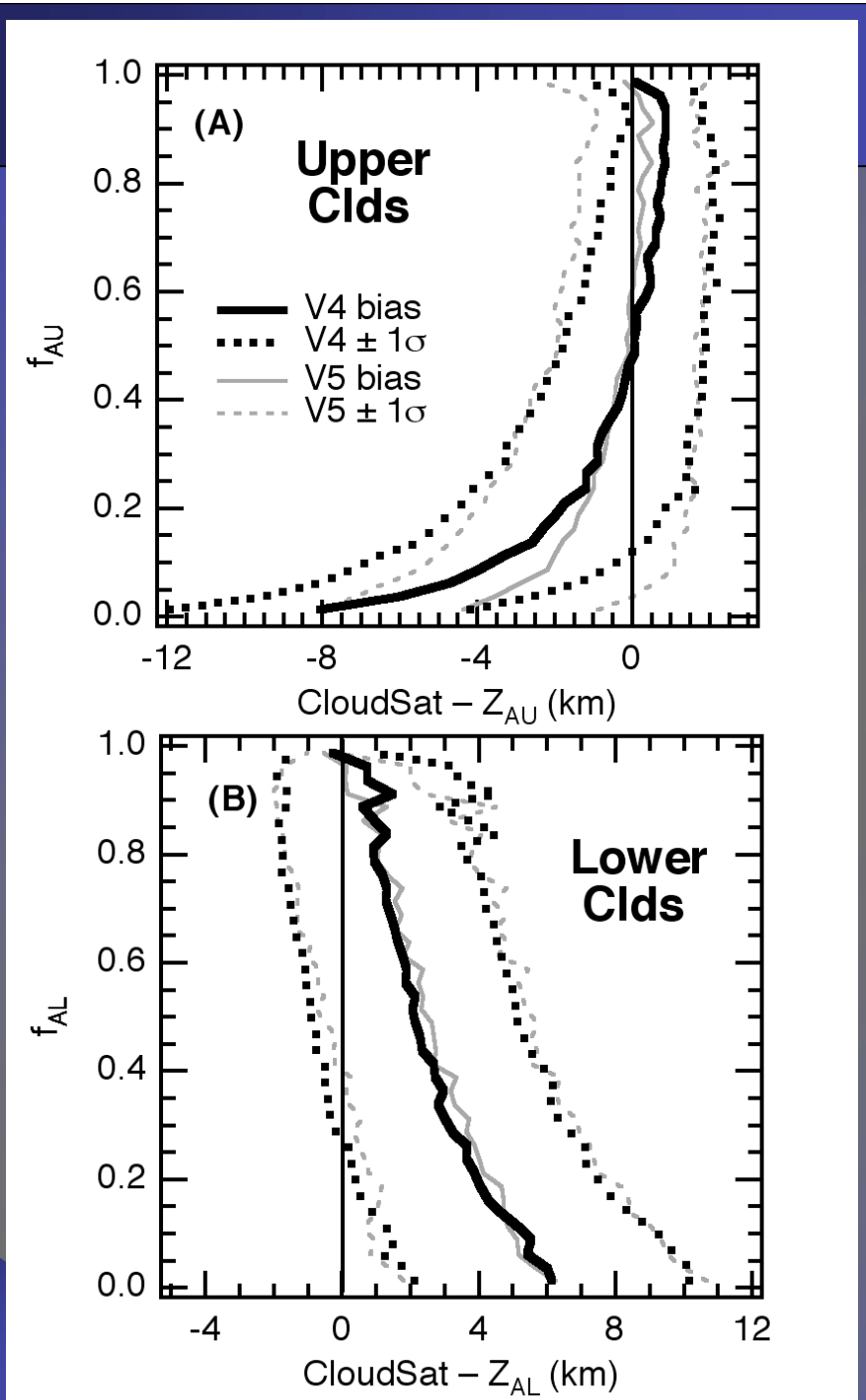


Joint pdfs of CloudSat- AIRS cloud top height differences as a function of f_A



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CloudSat - AIRS differences for AIRS v4 and v5 retrievals

Arctic clouds

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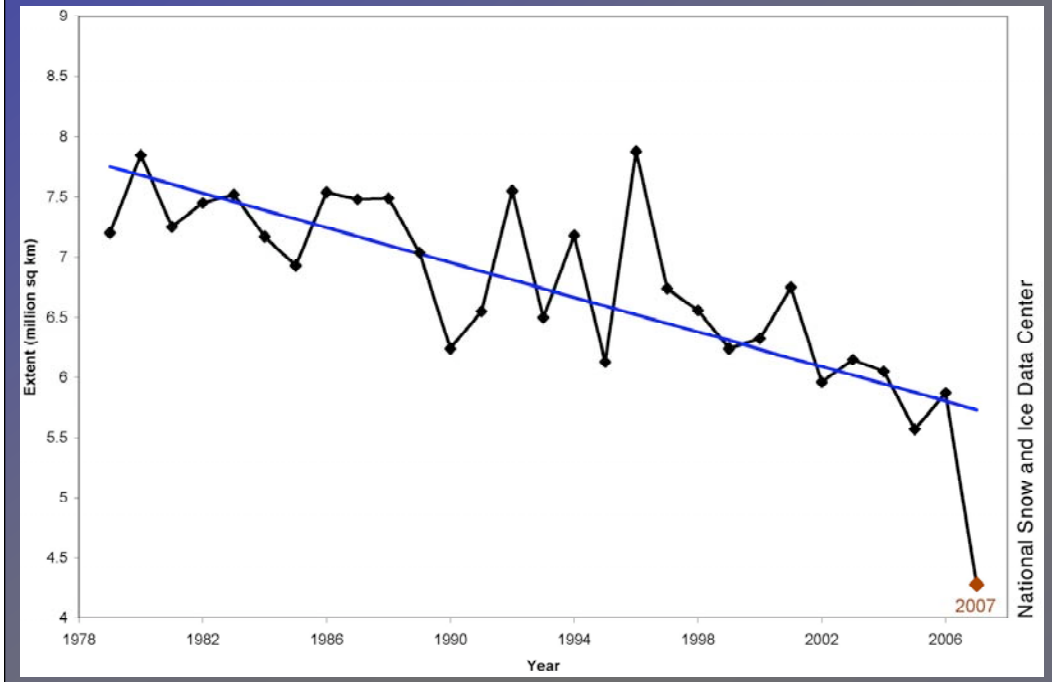
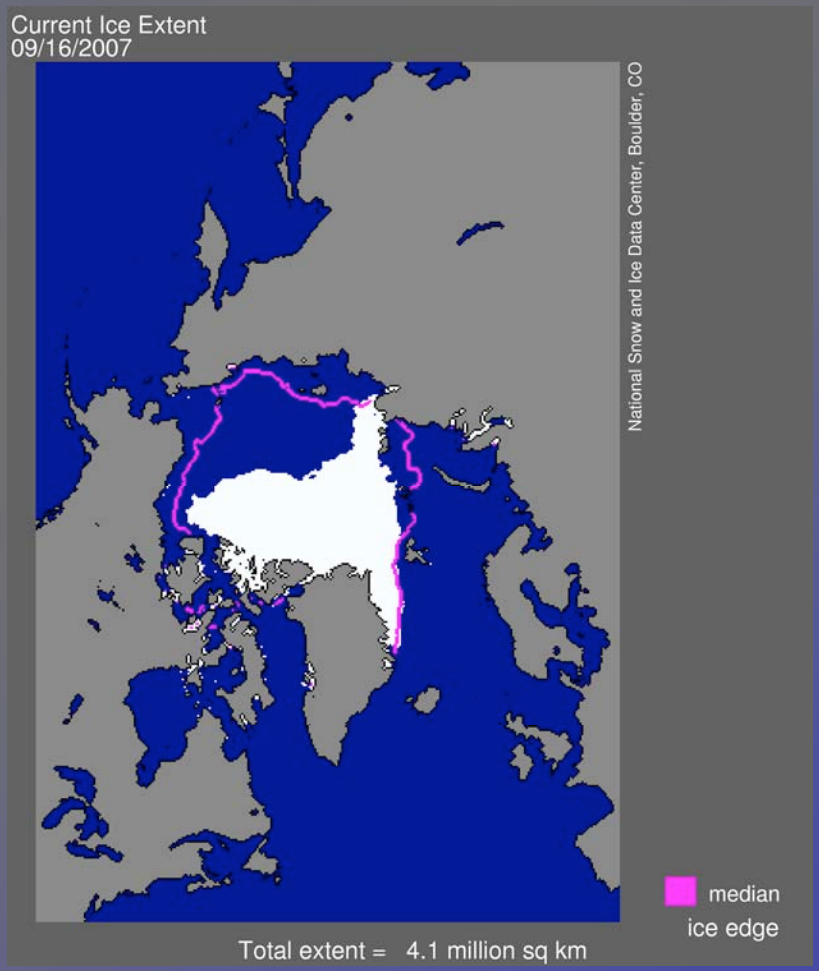


Minimum Extent Time Series



New Record Minimum - Sept. 2007

Kay et al., 2008

The A-train provides a unique view of Arctic clouds

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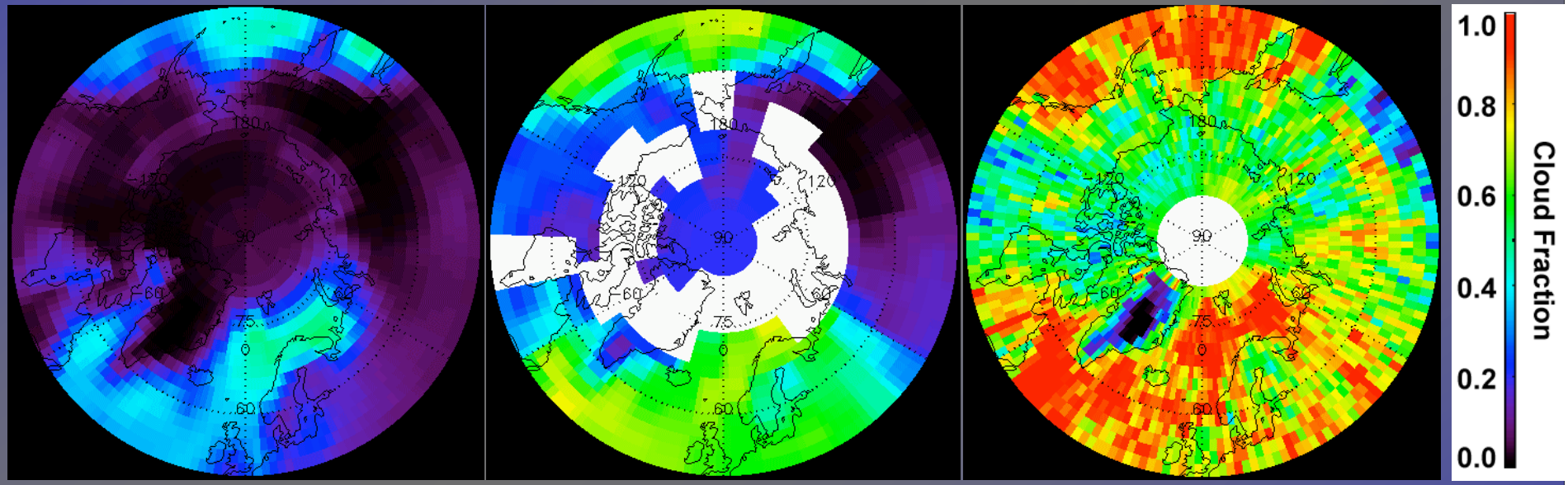
DJF Low Cloud Maps



ISCCP D2
(infrared)

Warren
(surface obs.)

2B-Geoprof-lidar

2007 Western Arctic Cloud Reductions

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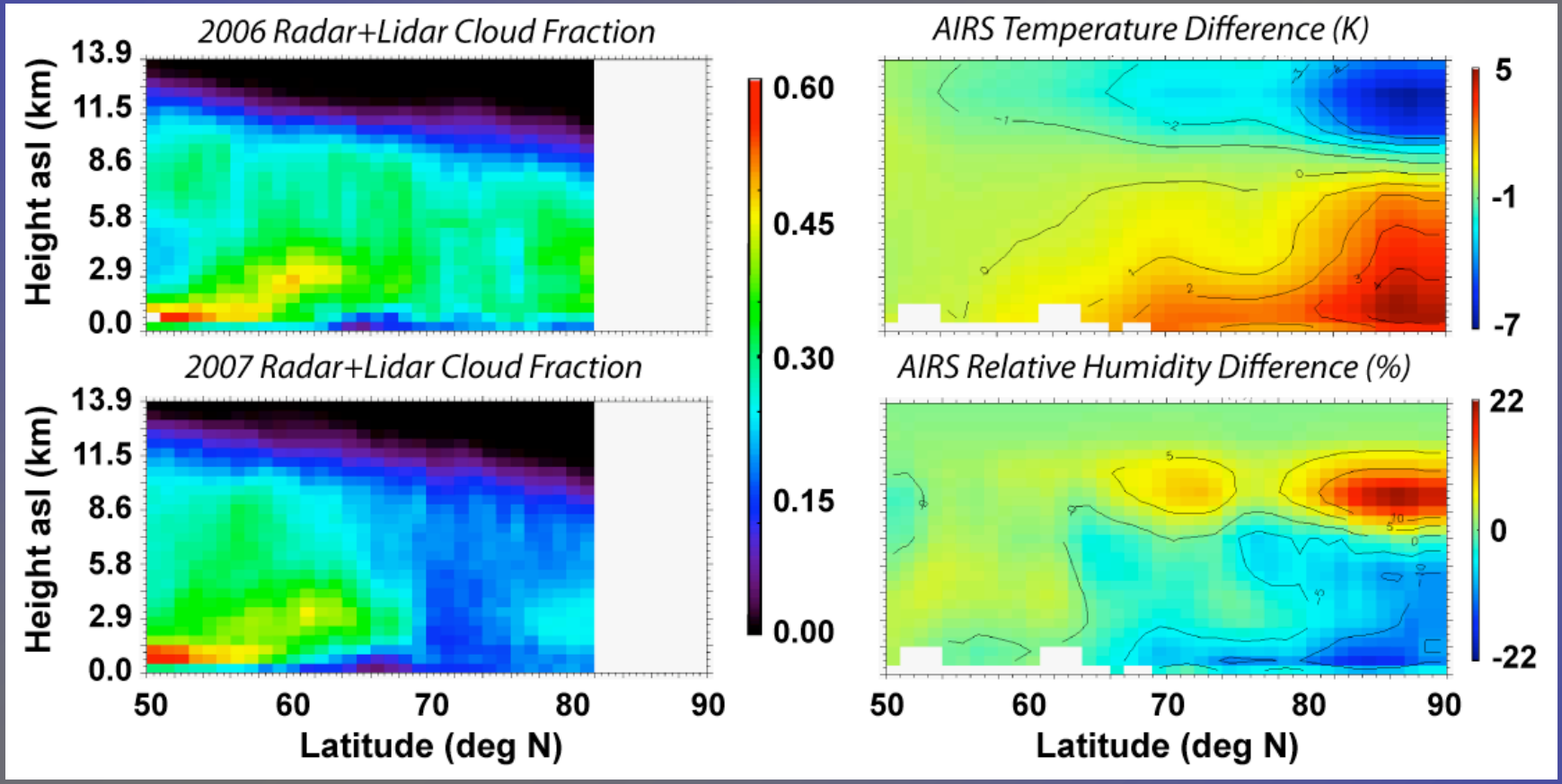

Kay et al., 2008

A-train data reveal dramatic cloudiness reductions, T increases, and RH decreases associated with the 2007 circulation anomalies.

Polar Surface Radiation Affect from Cloud Reduction

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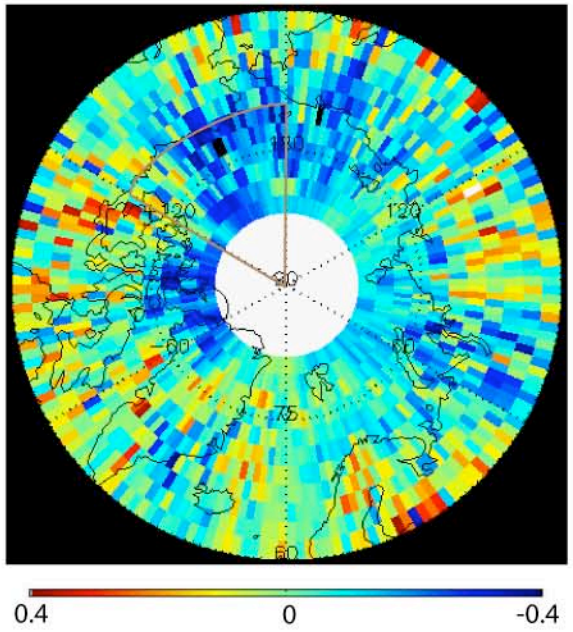
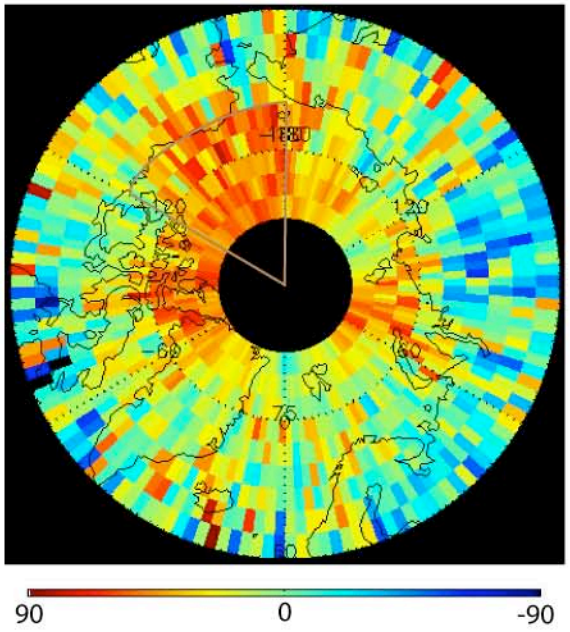
CloudSat/CALIOP Cloud Fraction



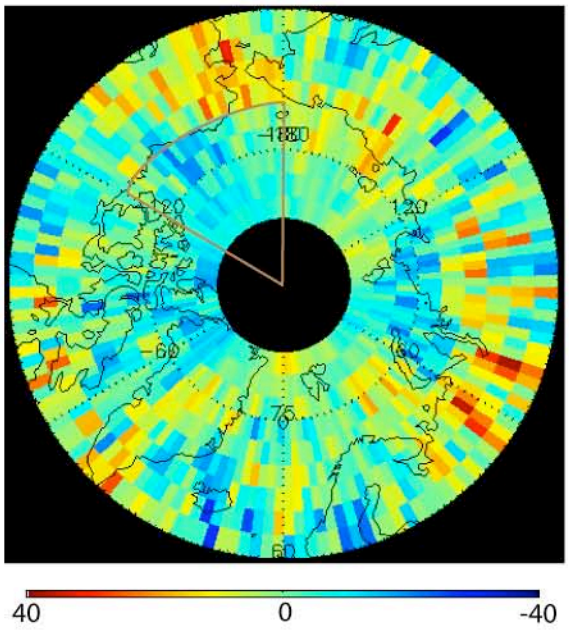
Western Arctic: -16%

Downwelling SW Radiation ($W\ m^{-2}$)



Western Arctic: + 32 $W\ m^{-2}$

Downwelling LW Radiation ($W\ m^{-2}$)



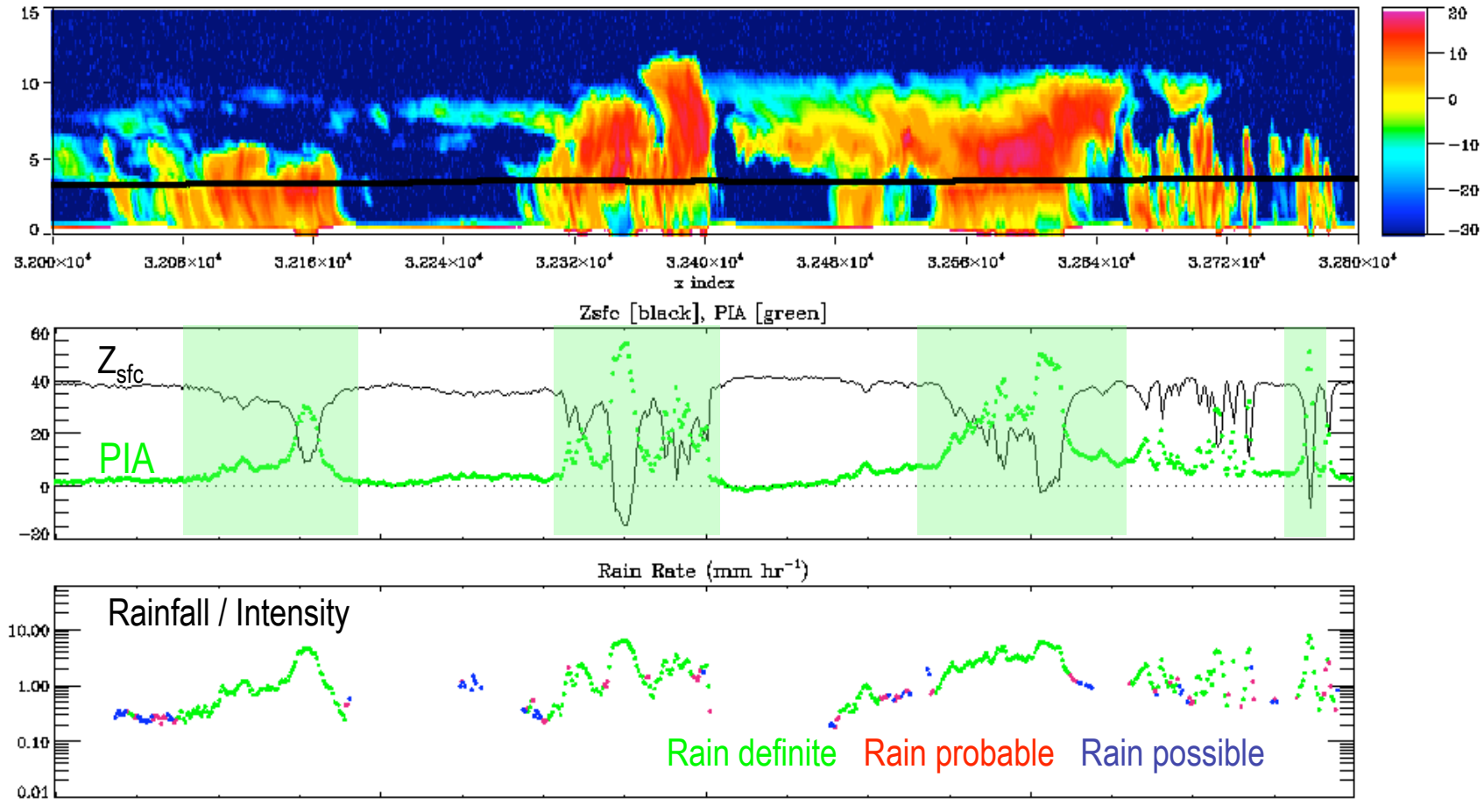
Western Arctic: - 4 $W\ m^{-2}$

2B-FIxhr

The 2007-2006 radiation differences could melt ~0.3 m of sea ice or increase ocean mixed layer temperatures by ~2.4 K.

Enhanced product: precipitation occurrence and amount

The PIA within a raining column can be estimated by the decrease in surface reflectivity from the clear sky background value: $PIA = Z_{sfc,clear} - Z_{sfc,obs}$



Extremely sensitive detector of rain - ~0.02 mm/hr

COADS comparison

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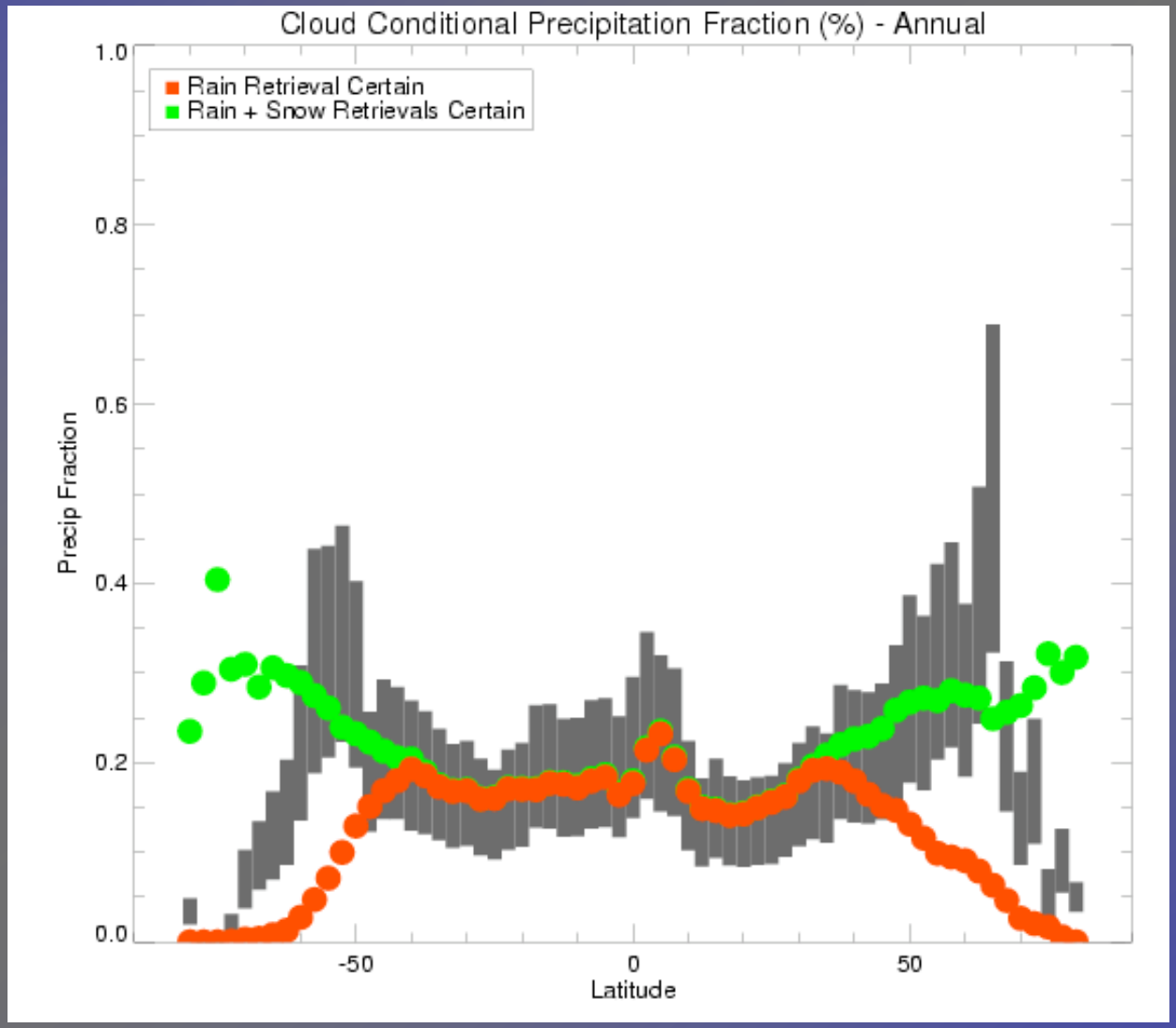

TRMM/CloudSatAMSR-E comparison of precipitation amount

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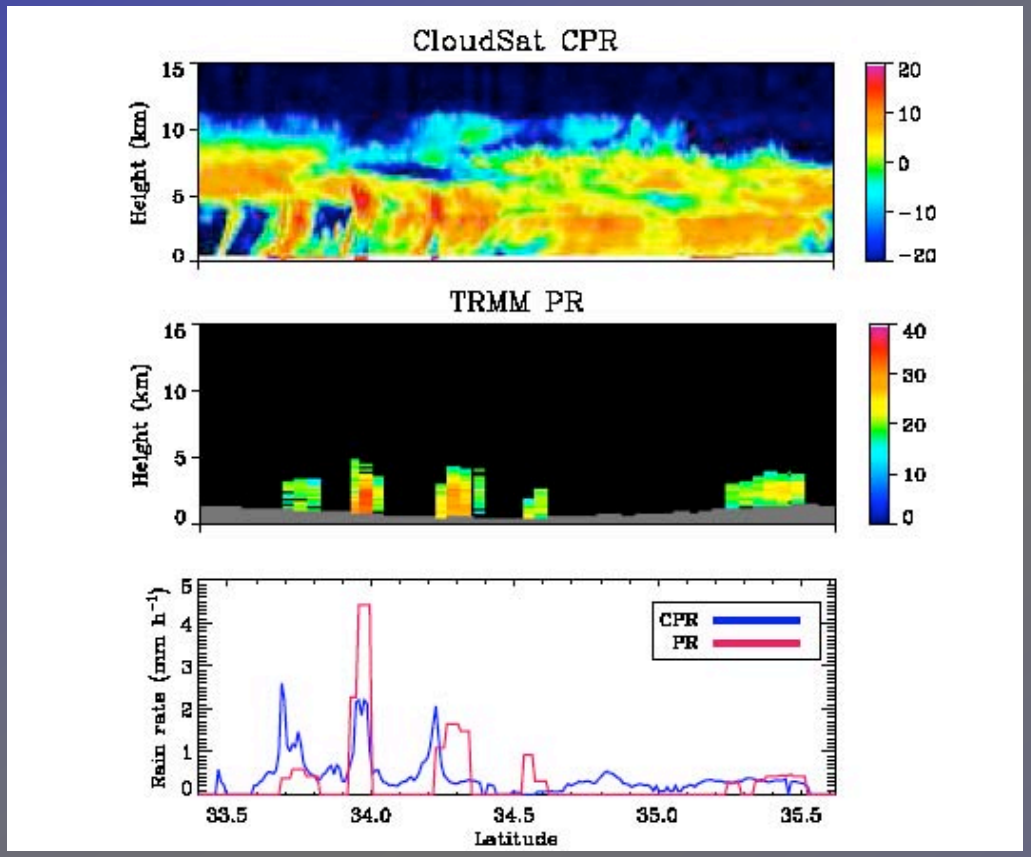

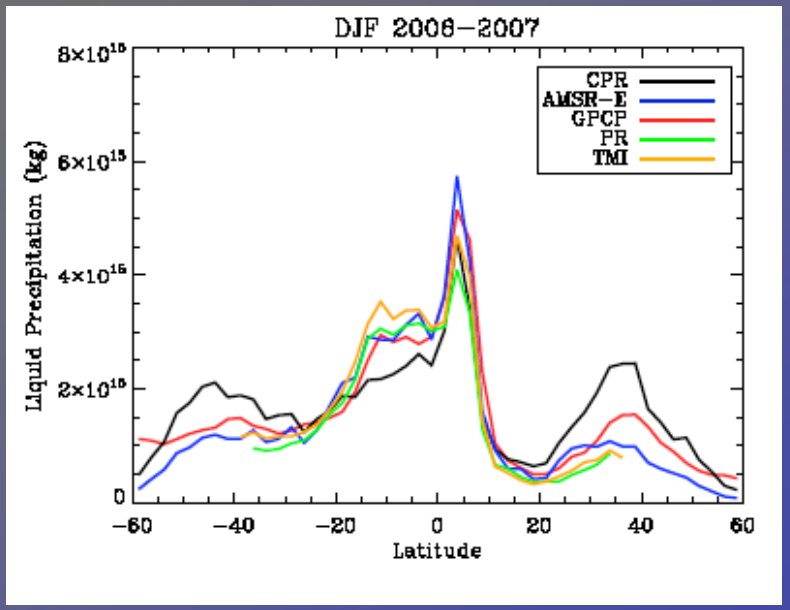

How Often Does it Rain (Over the Oceans) ?

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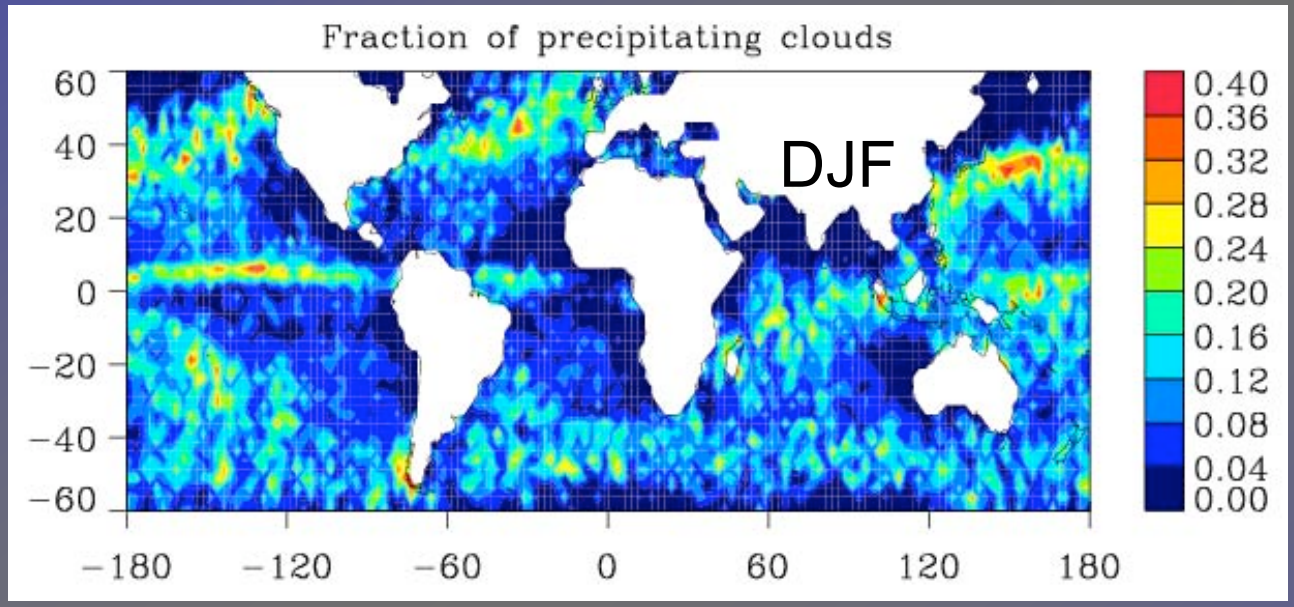
The Fraction of Oceanic Clouds That Precipitate



The global mean (oceans) value is ~0.13, i.e., on average, about 13 percent of the clouds observed over our oceans at any time are producing rain.

Stephens et al., 2008

Global Snowfall Occurrence

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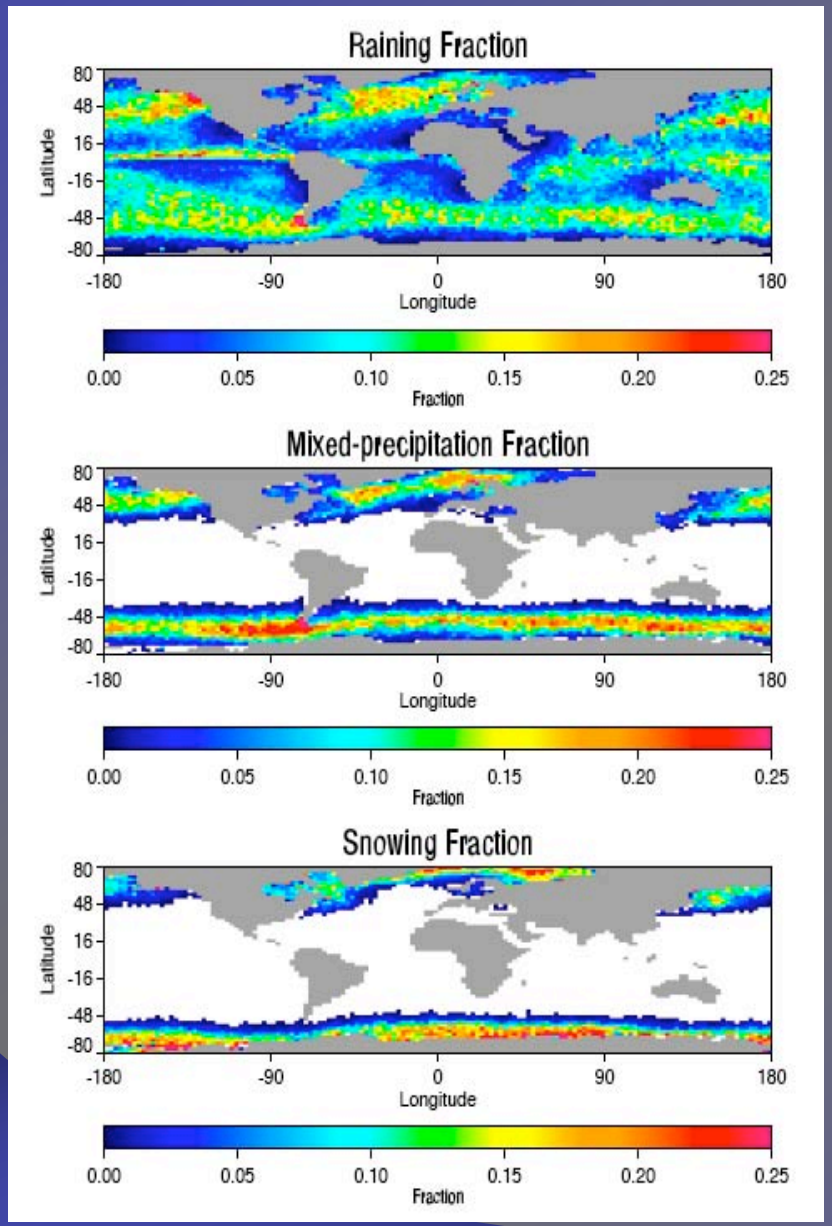

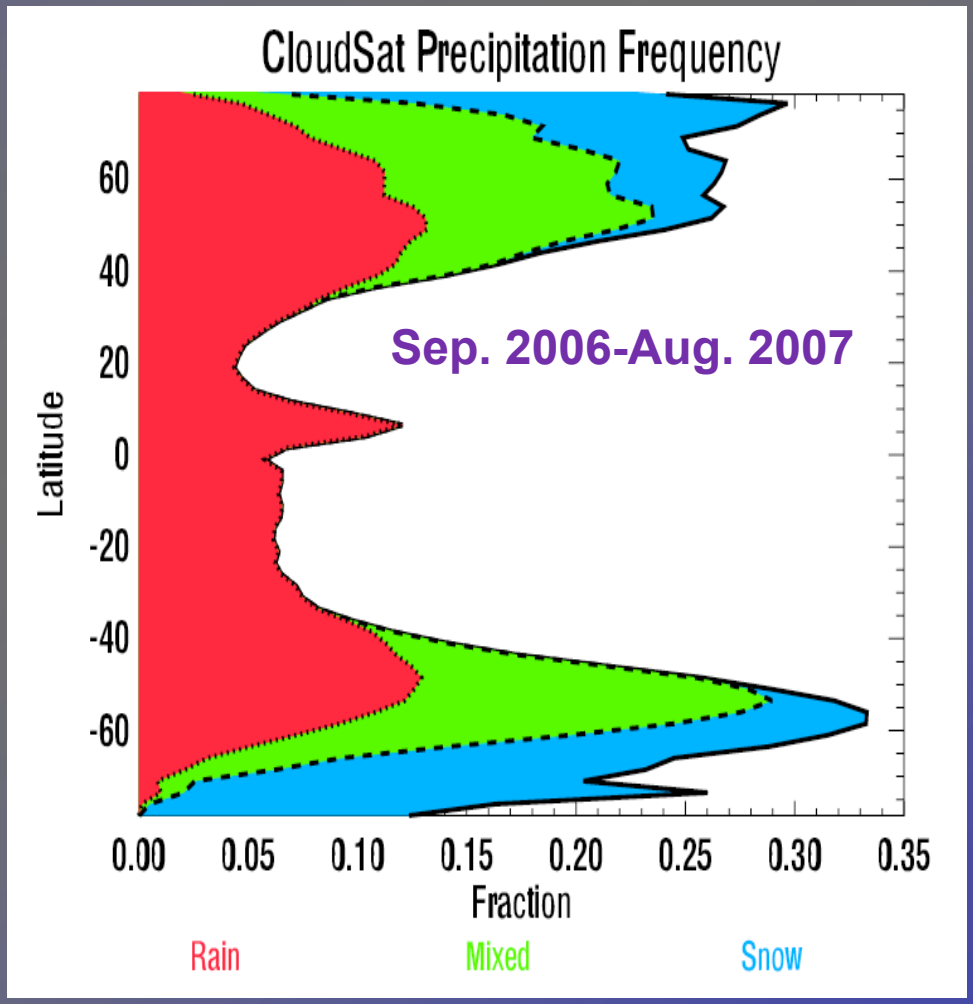

Do clouds heat or cool the atmosphere and by how much??

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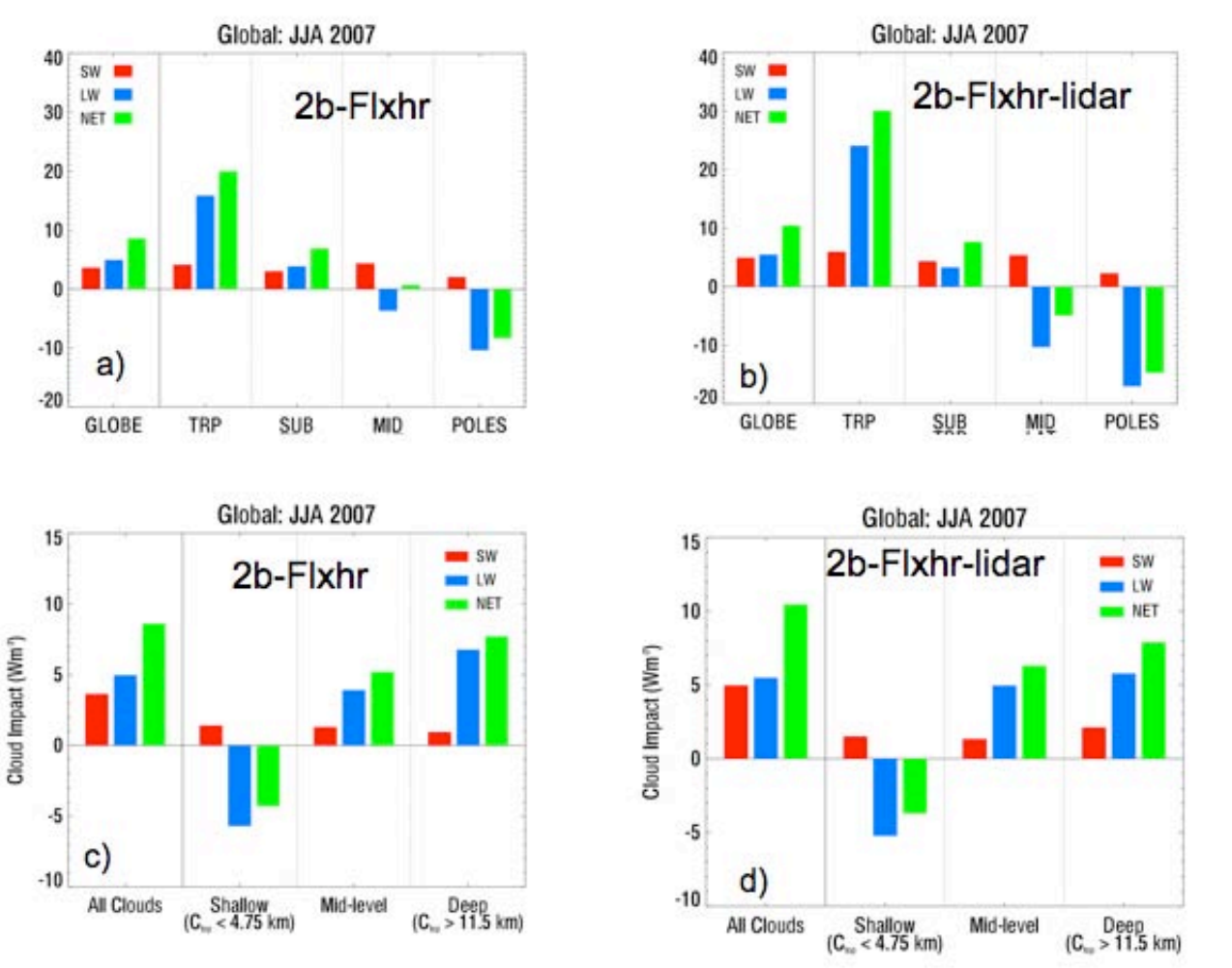

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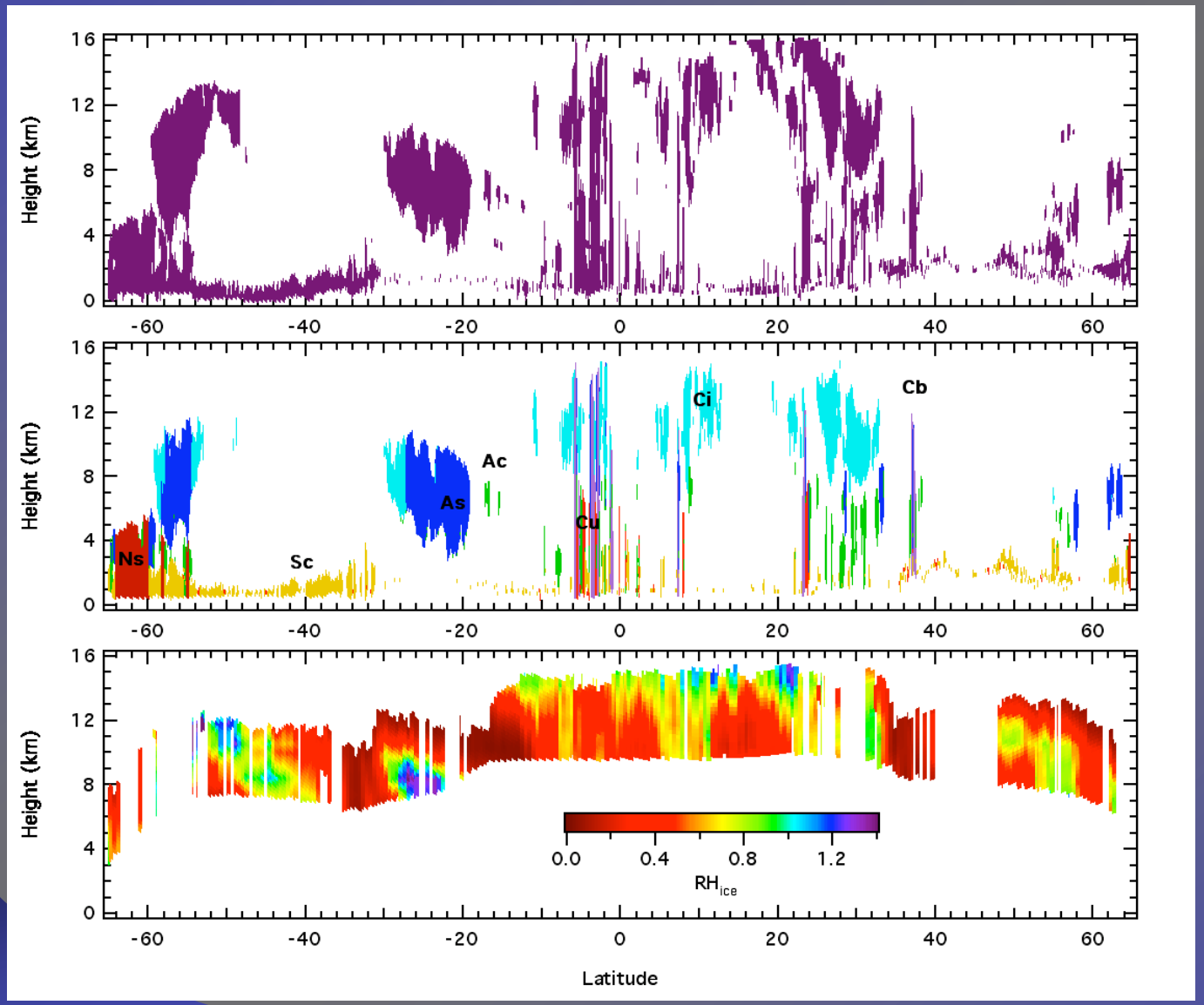

Radar + lidar cloud mask

Radar cloud classification

AIRS relative humidity

Summary

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- CloudSat successfully completed the prime mission and is now in extended mission phase. The flight system is healthy and we are optimistic for operations through at least FY11.

- All Level 2 products, and several co-located, auxilliary datasets, are released and available.

- Level 3 and enhanced products are under development.

- CloudSat observations can be used to determine the precision of AIRS-derived clouds in a wide variety of geophysical conditions, and allow comparisons to be made by cloud type.

    - Given the relatively favorable agreement between CloudSat and AIRS cloud heights, the AIRS swath is useful to supplement the near-nadir climatology from CloudSat.

- The intercomparison of A-Train datasets will lead to more reliable global datasets of cloud structure that will reduce the ambiguity in GCM-satellite comparisons.